Health Consultation

Elmwood Park Neighborhood

CHICAGO HEIGHTS BOULEVARD VOC PLUME SITE

OVERLAND, MISSOURI

DECEMBER 2, 2013

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR TOLL FREE at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

Elmwood Park Neighborhood

CHICAGO HEIGHTS BOULEVARD VOC PLUME SITE

OVERLAND, MISSOURI

Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Community Health Investigations
Western Branch

Table of Contents

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency (EPA) and the individual states regulate the investigation and cleanup of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and be stopped or reduced. If appropriate, ATSDR also conducts public health assessments and health consultations when requested by EPA or state agencies and petitioned by concerned individuals. Public health assessments and health consultations are carried out by environmental and health scientists from ATSDR and states with which ATSDR have cooperative agreements. The process allows ATSDR scientists and cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data are needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts might result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, might be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, pregnant women, and highly exposed people) also receive special attention during the evaluation.

ATSDR uses existing scientific information to evaluate the possible health effects that might result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn from the local community about the site and what concerns they might have about its impact on their health. Consequently, throughout the evaluation process, ATSDR frequently gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other regulatory agencies. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Manager, ATSDR Record Center, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (F-09), Atlanta, GA 30333.

SUMMARY

The Agency for Toxic Substances and Disease Registry (ATSDR) developed this health consultation to evaluate volatile organic compounds (VOCs) exposures in Elmwood Park neighborhood residents impacted by the Chicago Heights Boulevard VOC Plume Site. Volatile organic compounds from the EG&G/Missouri Metals Shaping Company facility, now owned by PerkinElmer, Inc., (PerkinElmer) are considered to be the source of the contaminants in soil that moved into the groundwater beneath the site. Contaminated groundwater has migrated beneath the adjacent Elmwood Park neighborhood. VOCs have volatilized from the groundwater into the soil gas beneath the residential neighborhood and into the living spaces of some homes. This process is referred to as soil vapor intrusion. Additionally, VOCs might be directly released into homes by way of groundwater seeping into basements. Many residents with basements use sump pumps to pump accumulated groundwater outside. This health consultation identifies potential hazards associated with the sub-slab vapor intrusion that are occurring in the Elmwood Park neighborhood.

Conclusions

The Agency for Toxic Substances and Disease Registry (ATSDR) has concluded that:

1. In the past, Elmwood Park residents at several homes/apartments might have been exposed to indoor air contaminated with trichloroethylene (TCE) at levels that could harm their health (i.e., an urgent public health hazard). In addition, indoor air TCE levels at other Elmwood Park homes/apartments might have in the past and could in the future increase to levels that could harm the health of residents. The health effect of greatest concern is the potential for cardiac malformations in children whose mothers were exposed to elevated levels of TCE during the first trimester of their pregnancy. If TCE exposures occurred for extended time periods, additional health effects of concern might include impacts on the immune system and kidney of children and adults.

2. The results of sampling conducted in August 2013 found TCE and other VOCs at homes (sub-slab soil gas and indoor air) in areas previously believed to be unaffected by the groundwater contamination and at levels which cannot be attributed to indoor sources. Therefore, basing future sampling locations solely on the known groundwater plume locations and proximity to another impacted home/apartment might not identify all impacted homes/apartments.

3. There are also other previously sampled homes/apartments that continue to have elevated sub-slab soil gas levels of TCE and other VOCs. Indoor air samples taken to date at these homes/apartments have not found TCE or other VOCs at levels of health concern. But indoor air levels of TCE and other VOCs that originate from sub-slab soil gas can vary because of seasonal, weather changes (e.g., heating and air conditioning systems being utilized, major storm fronts) and other factors; potentially resulting in exposes at levels of health concern.

4. The mitigation systems installed at homes/apartment found to have indoor air TCE levels above the US Environmental Protection Agency (EPA) reference concentration (RfC) have effectively reduced TCE in indoor air to levels that do not pose a health hazard.

Recommendations

Based upon the conclusions outlined above ATSDR recommends that:

1. EPA expand and expedite VOC testing of sub-slab soil gas and indoor air monitoring to include all the homes/apartments within the Elmwood Park neighborhood. If warranted by future sampling results, as the nature and extent of subsurface contamination and the conceptual site model are refined through further characterization and data evaluation, there might be a need to conduct monitoring beyond the Elmwood Park neighborhood.

2. Sub-slab soil gas and indoor air be collected concurrently as indoor air levels are not reliably predicted from the sub-slab measurements and indoor air levels might reflect contributions from sources other than vapor intrusion. The sub-slab monitoring defines which homes might be impacted; indoor air sampling results are used for estimating building occupants' exposures.

3. EPA continue taking prompt action to eliminate soil vapor intrusion and reduce indoor air levels, so that Elmwood Park neighborhood residents are not exposed to TCE at levels that might pose a health concern even for short-term exposures. It might be appropriate to implement temporary measures in advance of permanent building mitigation solutions.

4. Continued monitoring be conducted as needed for VOCs in sub-slab soil gas and indoor air at homes/apartments that have been mitigated to confirm that the mitigation systems continue to be effective in reducing exposures.

5. Periodic VOC monitoring be conducted as needed for both sub-slab soil gas and indoor air in homes/apartments that currently do not warrant mitigation systems, to ensure that future site conditions do not pose new health hazards.

To assist the community and other stakeholders ATSDR is working with the Missouri Department of Health and Senior Services to develop community engagement activities and is available to:

1. Answer people's questions about their health and the health of their children and assist in referring them to the Association of Occupational and Environmental Clinics (AOEC), American College of Medical Toxicology (ACMT), and Pediatric Environmental Health Specialty Unit (PEHSU).

2. Evaluate additional data and information from this site as it becomes available.

SITE DESCRIPTION AND BACKGROUND

A contaminated groundwater plume known as the Chicago Heights Boulevard VOC Plume Site lies beneath the Elmwood Park neighborhood in north St. Louis County. Although the extent of groundwater contamination is not completely characterized, it appears that 35 individual homes and 12 apartment buildings are potentially located in the area of the groundwater plume or contaminated soil-gas. The plume resulted from chemical releases at EG&G/Missouri Metal Shaping Company, a metal fabrication business located at 9970 Page Avenue, adjacent to the Elmwood Park neighborhood (EPA 2013). The groundwater contamination was discovered during the 1988 property transfer audit when PerkinElmer's predecessor acquired the property (EPA 2012a). PerkinElmer owns the property at 9970 Page Avenue and has been conducting environmental investigations at the site since that time, with oversight from Missouri Department of Natural Resources (MDNR) and subsequently EPA (EPA 2012a).

In 1998, groundwater contamination in the nearby Elmwood Park neighborhood was identified (MDNR 2001, Allen 2001). While area groundwater is not used as a drinking water source, volatile organic compounds (VOCs) in contaminated soils and groundwater might enter a building through basement walls, cracks in the foundations, and utility conduits through a process called vapor intrusion. When this occurs, building occupants might be exposed to these vapors.

Groundwater flow in the area appears to be in a southeasterly direction –which is toward the Elmwood Park neighborhood. Depth to groundwater varies across the area and changes because of rain events. Many basements in the area have sump pumps which collect groundwater that has seeped in through cracks in the foundations, walls, floors, as well as water that has drained from around the outside of the house (MDNR 2001, Allen 2001, EPA 2013). The Missouri American Water Company supplies public household water for local residents that is separate from the groundwater and subject to regular testing to ensure it is safe for consumption and use (EPA 2013).

Previous investigations identified the primary contaminants to be tetrachloroethylene (PCE), trichloroethylene (TCE), and their breakdown products (Allen 2001). MDNR, with concurrence from Missouri Department of Health (MDOH), recommended air and water sampling in the basements in the path of the plume to determine if contaminated groundwater was entering the basements and if indoor air was impacted (MDNR 2001). In August 2001, MDOH, in cooperation with ATSDR, released a health consultation for the Chicago Heights Boulevard VOC Plume Site. At that time, based on historic health based comparison values, it was concluded that cis-1,2 dichloroethylene, TCE, PCE, and chloroform detected in sump-pump water and/or basement air were not at levels expected to cause adverse health effects (MDOH 2001).

On July 31, 2012, the Missouri Department of Natural Resources (MDNR) referred the site to EPA for further investigation and cleanup (MDNR 2013). EPA Region 7 is overseeing PerkinElmer contractors who continue to sample sub-slab air and indoor air at homes and apartments in the area. This work began in 2012. As of August 2013, EPA has overseen the sampling activities at 47 Elmwood Park homes/apartments.

EPA has overseen the installation of vapor mitigation systems in homes where TCE was detected in indoor air at levels which posed a potential health risk for short term exposures. To date, vapor mitigation systems have been installed in five homes and one apartment. The most recent system was installed right after the August 2013 sampling results became available. These systems help to prevent contaminated sub-slab soil gas to enter homes/apartments. Testing continues in the neighborhood and additional mitigation systems might be installed in more homes, depending on the test results (EPA 2013).

DISCUSSION

Population at Risk

As discussed below, women of child bearing age, young children and developing fetuses are particularly susceptible to the adverse health effects associated with inhalation exposures to VOCs. Based on previous public meetings and one-on-one conversations with residents, ATSDR knows that these susceptible populations either reside, or visit, individuals residing in the Elmwood Park neighborhood for extended periods of time.

Sampling Results

To date, environmental investigations have included sampling of groundwater, ambient air, soil gas, residential sub-slab soil gas, water in basement sumps, and indoor air. Most of these samples were collected from homes/apartments known to be located over or close to the groundwater plume and the former EG&G/Missouri Metal Shaping Company facility.

In May and August 2012, air and sub-slab soil gas samples were collected from several homes. Mitigation systems have been installed in all homes where TCE exposures were of potential health concern. Subsequent monitoring confirms exposure levels have been reduced.

In September 2013, ATSDR received the expanded sub-slab soil gas and indoor air monitoring results from samples collected in several homes located beyond the known groundwater plume boundary. In order to provide a more complete understanding of the possible public health implications at the Chicago Heights Boulevard VOC Plume site, ATSDR reviewed all of the 2012-2013 sub-slab soil gas and indoor air sampling results.

Sub-Slab Soil Gas Contamination

EPA has overseen field work by PerkinElmer to sample the soil vapor beneath homes/apartments in the Elmwood Park neighborhood to determine if any homes/apartments are affected by the

VOCs in the shallow groundwater. The soil gas beneath homes/apartments immediately above the known groundwater plume was sampled first. Additional homes were sampled adjacent to the plume and adjacent to homes which had plume-related VOCs in the soil gas. In this way sampling has progressed across the neighborhood. EPA established site-specific screening levels for sub-slab sampling results. When sub-slab soil gas sampling results for VOCs are above EPA site-specific screening levels that indicates there is a higher potential for vapor intrusion; which could increase VOC indoor air levels. Where VOCs were detected above EPA site-specific screening levels, PerkinElmer's contractors sampled the air inside the homes/apartments to determine if VOCs had moved into the home/apartment and at what level.

Table 1 summarizes the Elmwood Park neighborhood sub-slab soil gas sampling results that were overseen by EPA (May 2012 – August 2013). To date, the PerkinElmer contractor has conducted sub-slab sampling at 47 homes/apartments (44 have had multiple sampling events). PCE concentrations in sub-slab soil gas samples exceeded the EPA site-specific screening level (93.6 $\mu g/m^3$) at 15 homes/apartments (ranging from 140 to 52,000 $\mu g/m^3$ at those locations) prior to mitigation. TCE concentrations in the sub-slab soil gas underneath 28 homes/apartments have exceeded the EPA site-specific screening level (4.3 $\mu g/m^3$) and ranged from 4.4 to 200,000 $\mu g/m^3$ prior to mitigation. When sub-slab soil gas sampling results find VOCs above EPA site-specific screening levels that indicates there is a higher potential for vapor intrusion, which could increase VOC indoor air levels. Other VOCs (i.e., 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene and vinyl chloride) were occasionally detected in sub-slab soil gas samples.

The sub-slab soil gas sampling results are spatially and temporally variable. For example, the home with the second highest sub-slab soil gas measurements (PCE at 52,000 $\mu g/m^3$ and TCE at 26,000 $\mu g/m^3$) appears to be several hundred feet beyond the groundwater plume and thus not a home that would typically be considered at risk for vapor intrusion. This observation makes it difficult to clearly define which homes/apartments might be at risk of having elevated indoor air levels of PCE and TCE.

Indoor Air Contamination

Based upon the sub-slab soil gas sampling results, 24-hour indoor air samples were taken at 27 homes/apartments (23 had multiple sampling events). Table 2 summarizes these results (May 2012 – August 2013). Analysis of the indoor air samples indicates that PCE and TCE were present in 25 and 23 of the homes/apartments, respectively. Indoor air levels were compared to health-based screening values for cancer and non-cancer health effects (Table 2). Where values exceeded these conservative screening values, the potential for adverse health effects is further discussed below in the Public Health Implications Section. PCE and TCE were not always detected above health-based comparison levels or detected in every sample. The highest PCE and TCE indoor air concentrations were found at homes/apartments that tended to have high PCE and TCE levels in sub-slab soil gas.

Indoor air sampling found TCE indoor air contamination above the EPA Reference Concentration (RfC, a health-based comparison value) at five homes and one apartment. Vapor mitigation systems have been installed at each of these locations. Indoor air samples taken after the installation of the vapor mitigation systems found that the TCE levels had dropped below the RfC; which indicates that the mitigation systems are preventing exposures to TCE above health-based screening levels in those homes/apartments.

To date, 1,1-dichloroethylene, cis-1,2-dichloroethylene, and trans-1,2-dichloroethylene have not been detected above health-based screening levels and will not be discussed further in this document. Vinyl chloride was only detected once and found at a level equal to the health-based screening level. A previous 24-hour air sample taken at that same location did not find vinyl chloride above health-based screening levels. Vinyl chloride will not be discussed further in this document because of the very low rate of detection.

Indoor Air Measurements Uncertainties and Variability

It is not uncommon to find PCE, TCE and other VOCs in indoor air (EPA 2011a). VOCs are found in common household products (e.g., paints, new carpeting and furniture, cigarette smoke, dry cleaned clothes) and can be a source of indoor air contamination. That might be why some of the indoor air samples taken in Elmwood Park homes/apartments found various VOCs when very little of those particular VOCs were found in sub-slab soil gas samples or in the plume of contaminated groundwater. In those situations, vapor intrusion might not be an important source of the detected VOCs and a sub-slab depressurization system (a common form of building mitigation) would not reduce indoor air VOC concentrations.

In addition, soil gas entry into buildings, which can carry VOCs into a building, can vary significantly over time and between buildings. The ability for sub-slab soil gas to enter homes/apartments is dependent upon many factors including the type of building construction, number and size of cracks in the building foundation/basement, and types of soil below and around the buildings (EPA 2002, EPA 2012b). In addition, indoor air levels of PCE and TCE will vary because of atmospheric and indoor air pressure changes (e.g., heating and air conditioning systems being utilized, major storm fronts) and other seasonal phenomena (e.g., rainfall events, fluctuation of water table elevation).

The contaminated groundwater can directly impact indoor levels of VOCs when the water table rises, enters the basement, and collects in a sump. Samples taken from sump water in some Elmwood Park homes/apartments have found elevated PCE and TCE which likely is contributing to the elevated indoor air PCE and TCE levels (EPA 2013) in some homes.

During the winter months, fresh air exchange is reduced because homes are closed more tightly. A stack effect commonly results due to the indoor to outdoor air temperature differential as well as the operation of many types of heating systems (EPA 212b). This stack effect tends to cause more sub-slab soil gas to enter homes/apartments at a greater rate during winter months in the continental United States. Therefore, indoor PCE and TCE air concentrations arising from vapor

intrusion can be expected to vary throughout the year and might be higher or lower than what was observed during any individual sampling event.

PUBLIC HEALTH IMPLICATIONS

VOCs, especially PCE and TCE, exist in the soil gas under several homes in the Elmwood Park neighborhood. PCE and TCE have been measured in the indoor air of several homes/apartments above health-based comparison levels. Levels of contaminants that exceed health-based comparison values do not mean adverse health effects will occur or are likely to occur. Comparison values are only used to help determine what contaminants need to be evaluated in more detail. The potential for exposed persons to experience adverse health effects depends on many factors, including:

(1) The amount of each chemical to which a person is or has been exposed;
(2) The length of time that a person is exposed;
(3) The route by which a person is exposed (inhalation, ingestion, or dermal absorption);
(4) The health condition of the person;
(5) The nutritional status of the person; and
(6) Exposure to other chemicals (such as cigarette smoke or chemicals in the work place).

The following sections provide a more complete evaluation of the public health implications of the PCE and TCE vapor intrusion, taking into consideration the specific needs for the susceptible population in the Elmwood Park neighborhood (Chicago Heights Boulevard VOC Plume site).

Tetrachloroethylene (PCE)

PCE (also known as perchloroethylene or PERC) is a nonflammable liquid at room temperature and is widely used for dry cleaning fabrics and for degreasing metal parts. It evaporates easily into the air and has a sharp, sweet-smelling odor. Most people can smell PCE in air at levels in excess of 7,000 µg/m^3. Because PCE can travel down through soils quite easily, it can make its way into underground water, where it might remain for a long time (ATSDR 1997).

Non-Cancer Health Effects of PCE

In February 2012, EPA established a reference concentration[1] (RfC) of 40 µg/m^3 for PCE (EPA 2012c). The RfC is an estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is unlikely to have deleterious effects during a lifetime of exposure.

[1] A reference concentration (RfC) is an US Environmental Protection Agency estimate, with uncertainty or safety factors built in, of the daily lifetime air concentration of a substance that is unlikely to cause harm in humans.

An RfC is generally developed by first determining the most sensitive target organ, and then identifying either a no observed adverse effect level (NOAEL) or the lowest exposure level where adverse health effects have been observed in animal or human studies (a.k.a., the lowest observed adverse health effect level [LOAEL]. PCE has two LOAELs: 15,000 µg/m^3 for neurotoxicity observed in workers involving color vision and 56,000 µg/m^3 for neurotoxicity involving reaction time and cognitive effects in workers according to EPA's Integrated Risk Information System (IRIS). Because the highest measured PCE level found in a home/apartment is below the EPA RfC, the actual measured indoor air levels do not represent a long term health concern.

ATSDR established an acute Minimal Risk Level[2] (MRL) of 1,400 µg/m^3 (ATSDR 1997). No PCE indoor air levels have been found to approach the ATSDR MRL. Therefore, the available data and information indicate that PCE exposures do not pose an acute health risk to Elmwood Park residents and visitors.

Cancer Risk of PCE

EPA has recently classified PCE as "likely to be carcinogenic to humans" by all routes of exposure. Although exposure to PCE has not been directly shown to cause cancer in humans, the U.S. Department of Health and Human Services has determined that PCE may reasonably be anticipated to be a human carcinogen (NTP 2011). The International Agency for Research on Cancer (IARC) has classified PCE as a Group 2A carcinogen—probably carcinogenic to humans (limited human evidence, sufficient evidence in animals) (IARC 1995).

EPA updated its health risk assessment for PCE in February 2012 (EPA 2012c). The Inhalation Unit Risk (IUR) was determined to be 2.6 x 10^{-7} per µg/m^3. The IUR is the excess lifetime cancer risk estimated to result from continuous exposure to a substance at a concentration of 1 µg/m^3 in air. Using this value and the maximum PCE concentration detected in the indoor air at this site, a possible worst case cancer risk from exposure to PCE can be estimated. Estimates of excess cancer risk are expressed as a proportion of the population that might be affected by a carcinogen during a lifetime of exposure. For example, an estimated risk of 1 x 10^{-6} predicts the probability of one additional cancer, over background, in a population of one million people exposed.

[2] A minimal risk level (MRL) is an Agency for Toxic Substances and Disease Registry estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable noncancerous risk of harm (adverse).

Using the highest PCE detected in an Elmwood Park neighborhood home to date as a potential worse-case situation (35 µg/m^3 – Table 1), the IUR (2.6 x 10^{-7} per µg/m^3) for PCE and assuming that the exposure was continuous throughout a lifetime (an unlikely situation), a lifetime cancer risk can be estimated as:

Cancer Risk = Inhalation Unit Risk x Air Concentration

Where,

Cancer Risk = estimated cancer risk (unitless)
Inhalation Unit Risk = (µg/m^3)$^{-1}$
Air Concentration = µg/m^3

Cancer risk = 2.6 x 10^{-7} per µg/m^3 x 35 µg/m^3 = 9.1 x 10^{-6}.

This represents about 0.91 possible excess cancer cases in a population of 100,000 over a lifetime of exposure. This is thought to represent a very low level of risk. The actual or true risk is likely to be less because exposure is likely to be intermittent (not 24 hours a day, 7-days a week, 52-weeks a year) and less than a lifetime (70 years). As discussed above, VOC levels in homes from vapor intrusion might vary greatly.

Trichloroethylene (TCE)

The primary industrial use of TCE was the degreasing of metal parts and its use was closely associated with the automotive and metal-fabricating industries from the 1950s through the 1970s (ATSDR 2013). When in surface soils, TCE will transform from a liquid to a gas faster than many other VOCs. The majority of the TCE spilled on soils close to the surface will vaporize into the air. When TCE is released into the air, it reacts relatively quickly in the presence of sunlight and oxygen, with about half of it breaking down to simpler compounds in about a week. TCE doesn't adsorb well to soil particles unless the soils have high organic carbon content. TCE is known to be only slightly soluble in water, but there is ample evidence that dissolved TCE remains in groundwater for a long time. Studies show that TCE in water will rapidly form a gas when it comes into contact with air (ATSDR 2013). TCE in groundwater can vaporize into the air spaces between adjacent soil grains. Studies indicate that it will then disperse by two primary routes; first, diffusion through the soil air spaces and then be re-adsorbed by groundwater or infiltrating rainwater, or second, it will migrate as a gas to the surface and be released to the atmosphere or nearby structures.

Non-Cancer Health Effects of TCE

In September 2011, EPA published an RfC of 2 µg/m^3 for chronic (long-term) inhalation exposure to TCE (EPA 2011b). The RfC is based on decreased thymus weight in female mice and increased fetal cardiac malformations in rats, with uncertainty factors built in. The EPA TCE RfC has been adopted by ATSDR as its chronic inhalation Minimal Risk Level (ATSDR 2013).

The RfC was derived from two principal studies (Johnson 2003; Keil 2009). The effect level for fetal cardiac malformations, based on a human equivalent concentration (HEC) derived from oral rat studies, is 21 µg/m^3 for three weeks during pregnancy with an uncertainty factor of 10 applied (Johnson 2003; EPA 2011). The HEC immunological effect level (specifically decreased thymus weights) was derived from oral mice studies is 190 µg/m^3 with an uncertainty factor of 100 applied (Keil 2009; EPA 2011). A supporting study of lower confidence indicated kidney effects at about 30 µg/m^3 (NTP 1988; EPA 2011). Depending upon the exposure dose and length, the immunological and kidney effects could potentially occur in children and adults.

Some TCE-associated adverse health effects have been documented after short-term exposures. For example, fetal cardiac malformations have been shown to occur in rats after only 3 weeks of exposure at a level that would be equivalent to humans breathing 21 µg/m^3 (Johnson 2003).

An epidemiologic study conducted in Endicott, New York found a statistically significant association between fetal cardiac malformations and maternal residence in areas with TCE soil vapor intrusion (Forand 2012). Although the study did not evaluate a dose-response relationship, it suggests that cardiac effects are the appropriate toxicological endpoint in humans and supports the use of the animal studies for developing the RfC. It also supports the extrapolation from oral to inhalation route of exposure in the TCE RfC derivation.

Using the highest indoor air TCE measured at the site (210 µg/m^3 – Table 1), ATSDR calculated a Hazard Quotient[3] (HQ) of 105 (210 µg/m^3 divided by 2 µg/m^3). A HQ of 105 with an uncertainty factor of only 10 and the TCE toxicological studies tends to indicate that adverse health effects might be possible in susceptible populations that are exposed to the measured level.

To date, two homes/apartments have had TCE indoor air levels greater than 21 µg/m^3 which is the human exposure level equivalent to the animal study that reported cardiac malformations (EPA 2011b). Thus, there is a concern for developmental effects if a woman was exposed even for a fairly short period of time (i.e., under three weeks) to these levels when the fetal heart is developing during the first trimester of pregnancy. Although the indoor levels of TCE have been reduced in those homes/apartments by the installation of mitigation systems, there is still a potential for exposures in other homes/apartments. As previously discussed, it is uncertain whether the measured levels in each home/apartment represent typical, worst-case, or best-case exposures. Conditions which increase vapor intrusion and raise indoor TCE levels could pose unhealthy conditions in the future. Thus, ATSDR cautions that homes with significantly elevated sub-slab levels of TCE are potentially at risk for indoor TCE air levels of health concern as site

[3] Hazard Quotient is a ratio of estimated site-specific exposure to a single chemical from a site over a specified period to the estimated daily exposure level, at which no adverse health effects are likely to occur

conditions change. There is also a potential for unidentified impacted homes/apartments within the Elmwood Park neighborhood that have not yet been investigated. Given the narrow time window for health effects on a developing fetus, ATSDR is concerned that unidentified or future exposures could pose an urgent public health hazard.

Cancer Risk of TCE

EPA recently classified TCE as "carcinogenic in humans by all routes of exposure." This conclusion is based on evidence of a causal association between TCE exposure in humans and kidney cancer (EPA 2011b). IARC has recently classified TCE as carcinogenic to humans (Group 1) (Guha 2012). The National Toxicology Program (NTP) determined that TCE is "reasonably anticipated" to be a human carcinogen (NTP 2011).

Analyses of seven studies of worker populations showed an association between exposure to high levels (greater than 500,000 $\mu g/m^3$) of TCE in air and an excess incidence of liver cancer, kidney cancer, non-Hodgkin's lymphoma, prostate cancer, and multiple myeloma. The strongest association was found for the first three of these cancers (NTP 2011). Agreement between human and animal studies supports the conclusion that TCE exposure might result in the development of kidney cancer. High doses are needed to cause liver toxicity and cancer in lab animals. Differences with regard to how humans and animals process TCE in the liver suggests that humans would be less susceptible to liver cancer from TCE exposures than the lab animals (ATSDR 2013).

The health effects, including increased cancer risks, from chronic exposure to low levels (single digit $\mu g/m^3$ range) of TCE in air and/or drinking water remain poorly-documented and largely unknown. ATSDR has recently derived a Cancer Risk Evaluation Guide (CREG)[4] of 0.24 $\mu g/m^3$ for exposures to TCE over a lifetime (over 70 years). CREGs are estimated contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime. The EPA recently updated its health risk assessment for TCE in September 2011 (EPA 2011b). The IUR was determined to be 4.1×10^{-6} per $\mu g/m^3$.

Using lowest and highest TCE monitored in-door air level (0.34 and 210 $\mu g/m^3$) and 2 $\mu g/m^3$, a range of cancer risk from exposure to TCE can be estimated with the formula:

Cancer Risk = Inhalation Unit Risk x Air Concentration

[4] A cancer risk evaluation guide (CREG) is a media-specific comparison value that is used to identify concentrations of cancer-causing substances that are unlikely to result in an increase of cancer rates in an exposed population.

Where,

Cancer Risk = estimated cancer risk (unitless)
Inhalation Unit Risk = $(\mu g/m^3)^{-1}$
Air Concentration = $\mu g/m^3$

Cancer risk = 4.1×10^{-6} per $\mu g/m^3 \times 0.34\ \mu g/m^3 = 1.4 \times 10^{-6}$
Cancer risk = 4.1×10^{-6} per $\mu g/m^3 \times 2\ \mu g/m^3 = 8.2 \times 10^{-5}$
Cancer risk = 4.1×10^{-6} per $\mu g/m^3 \times 210\ \mu g/m^3 = 8.6 \times 10^{-4}$

This represents about 0.14 to 86 possible excess cancer cases in a population of 100,000 over a lifetime of exposure. Exposure to the maximum TCE level detected in indoor air (210 $\mu g/m^3$) over a lifetime might be associated with an elevated cancer risk. However, the estimated risk might be lower because exposure is likely to be intermittent (not 24 hours a day, 7-days a week, 52-weeks a year) and less than a lifetime (70 years). Also, the vapor intrusion-related indoor air VOC levels probably vary greatly (higher and lower) over time. In addition, the indoor air sampling results reviewed for this Health Consultation only covers very limited time periods (discrete 24-hours samples taken periodically from May 2012 through September 2013); this makes it difficult to determine long-term exposures levels. Therefore, ATSDR cannot determine whether a significant cancer risk exists.

Exposure to Mixtures

ATSDR assessed the possibility that exposures to multiple VOCs in the Elmwood Park neighborhood complicate this assessment. The ATSDR Interaction Profile for 1,1,1-trichloethane, 1,1-dichloroethane, TCE, and PCE found no evidence for greater-than-additive interactions for liver, kidney, or developmental endpoints at exposure levels lower than those influencing the nervous system (ATSDR 2004). Because the exposure levels that have been documented to date at the Chicago Heights Boulevard VOC Plume site are below those found to cause nervous system effects, ATSDR's mixtures evaluation assumed only additive interactions were at play; and ATSDR has determined its health conclusions are not changed by assuming this additive risk.

Similarly, ATSDR's cancer risk evaluation for PCE and TCE would not be changed by assuming additive risks from multiple VOC exposures.

Summary of Public Health Implications

TCE-associated adverse health effects levels have been documented after short-term exposures. Fetal cardiac malformations have been shown to occur in rats after only 3 weeks of exposure at a level which would be equivalent to humans breathing 21 $\mu g/m^3$ (Johnson 2003). To date, two homes/apartments have had TCE indoor air levels greater than 21 $\mu g/m^3$. Thus, there is a potential for developmental effects if a women is exposed even for a fairly short period of time

(i.e., under three weeks) at these levels when the fetal heart is developing during the first trimester of pregnancy.

It is also important to consider that indoor air levels of TCE will vary because of atmospheric and indoor air pressure changes (e.g., heating and air conditioning systems being utilized, major storm fronts) and other seasonal phenomena (e.g., rainfall events, fluctuation on water table elevation). Conditions which increase vapor intrusion and raise indoor TCE levels could pose unhealthy conditions in the future. Thus, ATSDR cautions that homes with significantly elevated sub-slab levels of TCE are potentially at risk for indoor TCE air levels of health concern as site conditions change. There is also a potential for unidentified impacted homes within the Elmwood Park neighborhood homes/apartments that have not yet been investigated. Given the narrow time window for health effects on a developing fetus, ATSDR is concerned that unidentified or future exposures could pose an urgent public health hazard. If elevated TCE exposures occurred for extended periods of time additional health effects might be of concern and include impacts on the immune system and kidney.

CHILD HEALTH CONSIDERATIONS

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Children are shorter than adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health. TCE exposures are a particular concern during the development of the fetus (Johnson 2003, EPA 2011). Exposures during the critical fetal heart developmental period in the first trimester are of special concern. Our toxicity discussion above addresses these exposure concerns (ATSDR 2013).

CONCLUSIONS

The Agency for Toxic Substances and Disease Registry (ATSDR) has concluded that:

1. In the past, Elmwood Park residents at several homes/apartments might have been exposed to indoor air contaminated with trichloroethylene (TCE) at levels that could harm their health (i.e., an urgent public health hazard). In addition, indoor air TCE levels at other Elmwood Park homes/apartments might have in the past and could in the future increase to levels that could harm the health of residents. The health effect of greatest concern is the potential for cardiac malformations in children whose mothers were exposed to elevated levels of TCE during the first trimester of their pregnancy. If TCE exposures occurred for extended time

periods, additional health effects of concern might include impacts on the immune system and kidney of children and adults.

2. The results of sampling conducted in August 2013 found TCE and other VOCs at homes (sub-slab soil gas and indoor air) in areas previously believed to be unaffected by the groundwater contamination and at levels which cannot be attributed to indoor sources. Therefore, basing future sampling locations solely on the known groundwater plume locations and proximity to another impacted home/apartment might not identify all impacted homes/apartments.

3. There are also other previously sampled homes/apartments that continue to have elevated sub-slab soil gas levels of TCE and other VOCs. Indoor air samples taken to date at these homes/apartments have not found TCE or other VOCs at levels of health concern. But indoor air levels of TCE and other VOCs that originate from sub-slab soil gas can vary because of seasonal, weather changes (e.g., heating and air conditioning systems being utilized, major storm fronts) and other factors potentially resulting in exposures at levels of health concern.

4. The mitigation systems installed at homes/apartment found to have indoor air TCE levels above the US Environmental Protection Agency (EPA) reference concentration (RfC) have effectively reduced TCE in indoor air to levels that do not pose a health hazard.

RECOMMENDATIONS

Based upon these conclusions, ATSDR recommends that:

1. EPA expand and expedite VOC testing of sub-slab soil gas and indoor air monitoring to include all the homes/apartments within the Elmwood Park neighborhood. If warranted by future sampling results, as the nature and extent of subsurface contamination and the conceptual site model are refined through further characterization and data evaluation, monitoring beyond the Elmwood Park neighborhood might be required.

2. Sub-slab soil gas and indoor air be collected concurrently as indoor air levels are not reliably predicted from the sub-slab measurements and indoor air levels might reflect contributions from sources other than vapor intrusion. The sub-slab monitoring defines which homes might be impacted; indoor air sampling results are used for estimating building occupants' exposures.

3. EPA continue taking prompt action to eliminate soil vapor intrusion and reduce indoor air levels, so that Elmwood Park neighborhood residents are not exposed to TCE at levels that might pose a health concern even for short-term exposures. It might be appropriate to implement temporary measures in advance of permanent building mitigation solutions.

4. Continued monitoring be conducted as needed for VOCs in sub-slab soil gas and indoor air at homes/apartments that have been mitigated to confirm that the mitigation systems continue to be effective in reducing exposures.

5. Periodic VOC monitoring be conducted as needed of both sub-slab soil gas and indoor air in homes/apartments that currently do not warrant mitigation systems, to ensure that future site conditions do not pose new hazards.

To assist the community and other stakeholders ATSDR is working with the Missouri Department of Health and Senior Services to develop community engagement activities and is available to:

1. Answer people's questions about their health and the health of their children and assist in referring them to the Association of Occupational and Environmental Clinics (AOEC), American College of Medical Toxicology (ACMT), and Pediatric Environmental Health Specialty Unit (PEHSU).

2. Evaluate additional data and information from this site as it becomes available.

PREPARERS OF THIS REPORT

Gregory M. Zarus
Atmospheric Scientist and Geophysicist, ATSDR

Carole Hossom
Environmental Health Scientist, ATSDR

Tammie McRae
Environmental Health Scientist, ATSDR

Denise Jordan-Izaguirre
ATSDR Senior Regional Representative

LT Erin Harman, US Public Health Service
ATSDR Regional Representative

RADM Sven Rodenbeck, US Public Health Service (Retired)
Acting Western Branch Chief, ATSDR

REFERENCES

Allen, Brian J. 2001. Site Reassessment Investigation Report, Chicago Heights Boulevard VOC Plume Site, Overland Missouri. Missouri Department of Natural Resources, 24 April.

ATSDR (Agency for Toxic Substances and Disease Registry). 1997. Toxicological Profile for Tetrachloroethylene. U.S. Department of Health and Human Services (DHHS), Atlanta. September.

ATSDR. 2004. Interaction Profile for 1,1,1-Trichloroethane, 1,1-Dichloroethane, Trichloroethylene, and Tetrachloroethylene, U.S. DHHS. May.

ATSDR. 2013. Addendum to the Toxicological Profile for Trichloroethylene. U.S. DHHS, Atlanta. January.

EPA (U.S. Environmental Protection Agency). 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) Tables. EPA. November, 2002. EPA 530-D-02-004.

EPA. 2011a. Background Indoor Air Concentrations of Volatile Organic Compounds in North American Residences (1990-2005): A Compilation of Statistics for Assessing Vapor Intrusion. EPA. June 2011. EPA 530-R-10-001.

EPA. 2011b. Toxicological Review of Trichloroethylene. In Support of Summary Information on the Integrated Risk Information System (IRIS). Washington, DC. September.

EPA. 2012a. Administrative Settlement, Agreement and Order on Consent between EPA Region 7 and PerkinElmer, Inc., November 26. Available at http://www.epa.gov/region07/cleanup/chicago_heights/pdf/chicago_heights_aoc.pdf. Accessed September 20, 2013.

EPA. 2012b. Conceptual Model Scenarios for the Vapor Intrusion Pathway. EPA. February 2012. EPA 530-R-10-003.

EPA. 2012c. Toxicological Review of Tetrachloroethylene. In Support of Summary Information on the Integrated Risk Information System (IRIS). Washington, DC. February.

EPA. 2013. Frequently Asked Questions, Chicago Heights Boulevard Site, Updated June 2013, EPA Questions and Answers from Community Advisory Group (CAG), June. Available at http://www.epa.gov/region07/cleanup/chicago_heights/pdf/chicago_heights_faq.pdf Accessed September 23, 2013.

Forand S, Lewis-Michl E, Gomez M. 2012. Adverse Birth Outcomes and Maternal Exposure to

Trichloroethylene and tetrachloroethylene through soil vapor intrusion in New York State. Envirn Health Perspect, 120(4), 616-21.

IARC (International Agency for Research on Cancer). 1995. World Health Organization. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 63. Dry Cleaning, Some Chlorinated Solvents and Other Industrial Chemicals. 5. Summary of Data Reported and Evaluation.

Johnson, PD; Goldberg, SJ; Mays, MZ; Dawson, BV. 2003. Threshold of trichloroethylene contamination in maternal drinking waters affecting fetal heart development in the rat. Environmental Health Perspectives. V.11 (3) p. 289-292.

Keil, DE; Peden-Adams, MM; Wallace, S; Ruiz, P; Gilkeson, GS. 2009. Assessment of trichloroethylene (TCE) exposure in murine strains genetically-prone and non-prone to develop autoimmune disease. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering. V.44 (5) p. 443-453.

Missouri Department of Health. (MDOH). 2001. Chicago Heights Boulevard VOC Plume Site, St. Louis County, Missouri, ATSDR Health Consultation by Missouri Department of Health Under Cooperative Agreement with the Agency for Toxic Substances and Disease Registry. http://health.mo.gov/living/environment/hazsubstancesites/pdf/ChicagoHeights2001.pdf

Missouri Department of Natural Resources (MDNR) 2001. Site Reassessment Report, Chicago Heights Boulevard VOC Plume Site, St. Louis County, Missouri, MOSFN073551. http://dnr.mo.gov/env/hwp/sfund/12-19-2001-site-re-assessment-report.pdf.

MDNR. 2013. http://dnr.mo.gov/env/hwp/sfund/missourimetals-elmwoodpark.htm. Accessed September 26, 2013.

NTP (National Toxicology Program). 1988. Toxicology and Carcinogenesis Studies of Trichloroethylene (CAS No. 79-01-6) in four strains of rats (ACI, August, Marshall, Osborne-Mendel) (gavage studies). http://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/tr273.pdf . Accessed October 17, 2013.

NTP. 2011. Report on Carcinogens, Twelfth Edition; U.S. DHHS, Public Health Service, NTP, June 10.

Table 1
Sub-Slab Soil Gas Contaminant Levels (May 2012 – August 2013) Under Homes/Apartments, Chicago Heights Boulevard VOC Plume Site, Elmwood Park Neighborhood, Overland, Missouri

Contaminant	Detection (µg/m^3) Prior to Mitigation		Number of Locations Where Contaminant Detected Prior to Mitigation (Total Investigated = 47)	EPA Site-Specific Screening Level* (µg/m^3)	Number of Locations Where Contaminant Detected Above EPA Site-Specific Screening Levels Prior to Mitigation	Detection (µg/m^3) at Locations Not Mitigated To Date		Number of Locations Not Mitigated To Date Where Contaminant Detected Above EPA Site-Specific Screening Levels
	Minimum	Maximum				Minimum	Maximum	
Tetrachloroethylene	3.3	52,000	23	93.6	15	3.3	2,500	11
Trichloroethylene	0.34	200,000	31	4.3	28	0.34	4,000	22
1,1-Dichloroethylene	2.1	4.3	2	2,100	0	2.1	2.1	0
Cis-1,2-Dichloroethylene	1.6	21,000	10	73	7	1.6	1,200	3
Trans-1,2-Dichloroethylene	4.2	810	3	630	2	ND	ND	0
Vinyl Chloride	0.3	26	3	1.6	3	0.3	26	2

VOC – Volatile organic compounds
µg/m^3 – Micrograms per cubic meter
EPA – US Environmental Protection Agency
* – EPA Site-Specific Screening Levels are developed to help determine when sampling results indicate that additional follow-up or action might be needed such as sampling the indoor air of the home/apartment.
ND – None Detected

Table 2
24-Hour Indoor Air Contaminant Levels (May 2012 – August 2013) Within Homes/Apartments, Chicago Heights Boulevard VOC Plume Site, Elmwood Park Neighborhood, Overland, Missouri

Contaminant	Detection (µg/m^3) Prior to Mitigation		Number of Locations Where Contaminant Was Detected Prior to Mitigation (Total Sampled = 27)	Health-Based Screening Level* (µg/m^3)	Number of Locations Where Contaminant Detected Above Health-Based Screening Levels Prior to Mitigation	Detection (µg/m^3) at Locations Not Mitigated To Date		Number of Locations Not Mitigated To Date Where Contaminant Detected Above Health-Based Screening Levels
	Minimum	Maximum				Minimum	Maximum	
Tetrachloroethylene	0.076	35	25	40 RfC	0	0.08	2.3	0
				3.8 CREG	3			0
Trichloroethylene	0.12	210	23	2 MRL/RfC	6	0.16	1.9	0
				0.24 CREG	22			16
1,1-Dichloroethylene	0.052	0.21	2	79 Intermediate EMEG	0	0.052	0.21	0
Cis-1,2-Dichloroethylene	0.055	71	11	79 Intermediate EMEG**	0	0.14	0.65	0
Trans-1,2-Dichloroethylene	0.094	0.9	2	790 Intermediate EMEG	0	ND	ND	0
Vinyl Chloride	0.16	0.16	1	100 RfC	0	0.16	0.16	0
				0.11 CREG	1			1

VOC – Volatile organic compounds
$\mu g/m^3$ –Micrograms per cubic meter
* – Health-based screening levels are contaminant-specific concentrations at which health effects are unlikely. Contaminants that exceed health-based screening levels do not mean adverse health effects are likely; rather, it means a more detailed evaluation is necessary.
RfC – Reference Concentration, developed by the US Environmental Protection Agency, is an estimate, with uncertainty or safety factors build in, of the daily lifetime air concentration of a substance that is unlikely to cause harm in humans.
CREG – Cancer Risk Evaluation Guide, developed by ATSDR, is a media-specific comparison value that is used to identify concentrations of cancer-causing substances that are unlikely to result in an increase of cancer rates in an exposed population after a lifetime of exposure.
MRL – Minimal Risk Level, developed by Agency for Toxic Substances and Disease Registry (ATSDR), is an estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harm (adverse), noncancerous effects.
EMEG – Environmental Media Evaluation Guide," developed by ATSDR, represent concentrations of substances in water, soil, and air to which humans might be exposed during a specified period of time (acute, intermediate or chronic)without experiencing adverse health effects.
** – Used the 1,1-Dichloroethylene health-based screening level.
ND – None Detected